Synthesis and spectroscopic characterization of some chromanochalcones and their dihydro derivatives

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This paper is dedicated to Professor P. Srinivasa Rao on the occasion of 65th birthday
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Abstract
Synthesis of naturally occurring 6-(α,β-dihydrocinnamoyl)-3,4-dihydro-2H-chromanes has been carried out by the reaction of 6-acetyl-3,4-dihydro-2H-chromanes with methoxybenzaldehydes followed by hydrogenation of the resulting 6-cinnamoyl-3,4-dihydro-2H-chromanes.

Keywords: Chromanochalcones, chromano dihydrochalrones, hydrogenation, NMR spectroscopy

Introduction

Flavonoids are phenol derivatives present in substantial amounts (0.5–1.5%) in plants1 in which they carry out important functions for their biochemistry and physiology.2 These compounds contribute to color, flavor and processing characteristics important in many foods (vegetables, fruits) and in drinks (tea, wine). Food from common plants contain from traces up to several grams per kg fresh weight of flavanoids.3 Biological properties of flavonoids and their pharmaceutical potencies have been widely investigated and extensively reviewed during the past 30 years.4 Dihydrochalrones comprise a small group of compounds chemically and biochemically very closely related to chalcones. The utilization of certain dihydrochalrone derivatives and related compounds as sweetening agents has been reported.5

Previously, we have isolated chalcones 5aa, 5ab, 5ba, and 5bb (Scheme 1) in our laboratory from the Indian medicinal plant species crotalaria. Here we have undertaken the synthesis of these dihydrochalrones. The aim of the current synthetic study was to provide clear and easy
access to prenylated dihydrochalcones with the saturation and unsaturation in α- and β- positions and also in the chromane part. Our strategy was the construction of 6-acetylchromanes 2a and 2b by condensation of 2,4-dihydroxyacetophenone (1) with isoprene in presence of Amberlyst 15, followed by the condensation with methoxybenzaldehydes 3a,b to afford the target chromanochalcones.6,7

Results and Discussion

2,4-Dihydroxyacetophenone (1) can be obtained from commercially available resorcinol by reaction with acetyl chloride and zinc chloride. It was reacted with 2-methylbuta-1,3-diene in the presence of sulfonic acid cation exchange resin Amberlyst 15 in THF to give two regioisomeric acetylchromanes, 1-(5-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)ethanone (2a) and 1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)ethanone (2b) (Scheme 1).

![Scheme 1](attachment:scheme1.png)

Treatment of the 6-acetylchromanes 2a,b with methoxybenzaldehydes 3a (R³ = R⁴ = H) and 3b (R³ = R⁴ = OMe) in basic media [Ba(OH)₂ in EtOH] afforded the corresponding chromanochalcones 4aa, 4ab and 4ba, 4bb, respectively. Except 4ab, all chalcones have been described before.8 Finally, the respective dihydrochalcones 5 were synthesized by reduction of chalcones 4 with sodium formate in Pd/C. Only 5ba has been reported in the literature.8

The structures of all compounds were determined by electron-impact mass spectrometry and by 1D and 2D NMR spectroscopy (DEPT, ¹H,¹H-COSY, HMBC, HMQC). Thereby, all ¹H and ¹³C signals could be assigned, and the atomic connectivities were established unambiguously (Tables 1 and 2). The easiest way to differentiate the regioisomers of products 4 and 5 was the
inspection of the two aromatic protons 7,8-H (aa, ab) and 5,8-H (ba, bb), respectively, which are either in ortho- or in para-position with respect to each other; accordingly, these signals appeared as doublets ($J = 8–9$ Hz) or as singlets ($J < 1$ Hz), respectively.

The $^1$H NMR spectra of the chalcones show a signal for a chelated aromatic hydroxyl group in between $\delta$ 13.0 and 14.0, and in addition signals of aromatic methoxyl groups and aromatic protons. The two sharp doublets between $\delta$ 7.0–8.0 with $J = 15.3$ Hz are characteristic of the trans double bond of chalcones 4. All NMR data are compiled in Tables 1 and 2.

**Table 1.** $^1$H Chemical shifts and $^1$H,$^1$H coupling constants $J$ [Hz] of compounds 2, 4, and 5; in CDCl$_3$ at 400.1 MHz. For atom numbering see structure 4 in Scheme 1

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Experimental Section

General Procedures. The NMR spectra of CDCl$_3$ solutions were recorded using a Bruker DPX-400 spectrometer ($^1$H: 400.1 MHz; $^{13}$C: 100.6 MHz). Standard Bruker software was employed for all one- and two-dimensional experiments. $^1$H and $^{13}$C NMR spectroscopic data are compiled in Tables 1 and 2. Electron impact mass spectra (70 eV) were obtained from a Finnigan MAT-312 instrument. All solvents were purified and distilled prior to use. Column chromatography was performed on silica gel (Merck 60, 70–230 mesh). Thin-layer chromatography was performed using pre-coated aluminum TLC plates of silica gel (60 F$_{254}$).
1-(5-Hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)ethanone (2a) and 1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)ethanone (2b). To a stirred solution of Amberlyst-15 (6.2 g) and 1-(2,4-dihydroxyphenyl)ethanone (1) (4.56 g, 30 mmol) in THF (10 mL) at 65–70 °C isoprene (3.2 mL, 47 mmol) in heptane (10 mL) was added dropwise over a period of 2 h. The reaction mixture was filtered and washed with hot acetone (2 x 50 mL) and separated by column chromatography using as eluants hexane/ethyl acetate (8:2 and 6:4) thus affording 2a (2.8 g, 43%) and 2b (0.95 g, 15%).

2a: mp 70 °C. EI-MS: m/z (%) 220 (55) [M+], 205 (19), 177 (21), 165 (100), 147 (14). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C13H16O3: C, 70.87; H, 7.31. Found: C, 70.82; H, 7.29.

2b: mp 118 °C. EI-MS: m/z (%) 220 (43) [M+], 205 (25), 177 (4), 165 (100), 147 (7). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C13H16O3: C, 70.87; H, 7.31. Found: C, 70.93; H, 7.40.

(2E)-1-(5-Hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(4-methoxyphenyl)prop-2-en-1-one (4aa), (2E)-1-(5-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(2,4,5-trimethoxyphenyl)prop-2-en-1-one (4ab), (2E)-1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(4-methoxyphenyl)prop-2-en-1-one (4ba), and (2E)-1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(2,4,5-trimethoxyphenyl)prop-2-en-1-one (4bb). To a solution of chromanes 2 (150 mg, 0.69 mmol) was added Ba(OH)2 (150 mg, 0.9 mmol) and a solution of 3a (204 mg, 1.5 mmol) in ethanol (5 mL), and the mixture was stirred at 35–40 °C for 6 h. After dilution with water (100 mL) and acidification with cold diluted hydrochloric acid (25 mL) the resulting solid was filtered off, washed with water and recrystallized from petroleum ether to give yellow needles 4aa (168 mg, 73%); mp 82–83 °C. EI-MS: m/z (%) 338 (5) [M+], 314 (3), 246 (4), 220 (57), 205 (19), 177 (23), 165 (100), 149 (28), 135 (16), 107 (10), 94 (15), 77 (12). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C21H22O4: C, 74.51; H, 6.53. Found: C, 74.57; H, 6.58.

Treatment of 2a with 3b under the same conditions gave orange needles 4ab (172 mg, 63%); mp 104–106 °C. EI-MS: m/z (%) 398 (54) [M+], 367 (100), 311 (14), 194 (45), 181 (51), 149 (28). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C23H26O6: C, 69.35; H, 6.57. Found: C, 69.41; H, 6.66.

Analogously, the reaction of compound 2b with methoxybenzaldehydes 3a and 3b afforded yellow needles 4ba (160 mg, 69%) and 4bb (163 mg, 60%), respectively.

4ba: mp 146–147 °C. EI-MS: m/z (%) 338 (100) [M+], 321 (5), 284 (24), 231 (15), 204 (33), 189 (7), 161 (9), 149 (67), 134 (56), 121 (33). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C21H22O4: C, 74.51; H, 6.53. Found: C, 74.53; H, 6.55.

1-(5-Hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(4-methoxyphenyl)propan-1-one (5aa), 1-(5-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(2,4,5-trimethoxyphenyl)propan-1-one (5ab); 1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(4-methoxyphenyl)propan-1-one (5ba), and (2E)-1-(7-hydroxy-2,2-dimethyl-3,4-dihydro-2H-chromen-6-yl)-3-(2,4,5-trimethoxyphenyl)prop-2-en-1-one (5bb). To a solution of chromano-chalcone 4aa (250 mg, 0.74 mmol) and sodium formate (1.0 g, 14.7 mmol) in methanol (25 mL) was added Pd/C (10%, 250 mg, 0.5 mmol), and the mixture was refluxed for 30–45 min. After the catalyst was removed by filtration, the solvent was distilled off, the residue was treated with water, and the product was extracted with ether. The ether solution was washed with water, dried over sodium sulfate, and the solvent was removed by evaporation. The residue 5aa (230 mg, 92%) was essentially pure to get spectral data; mp 102–104 °C. EI-MS: m/z (%) 341 [M++H] (17), 323 (4), 205 (6), 178 (10), 149 (12), 134 (8), 121 (20), 49 (100). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C21H24O4: C, 74.07; H, 7.09. Found: C, 74.11; H, 7.14.

5ab. The same treatment of compound 4ab afforded 5ab (210 mg, 83%); mp 126–128 °C. EI-MS: m/z (%) 400 (54) [M⁺], 367 (100), 311 (14), 194 (45), 181 (51), 149 (28). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C23H28O6: C, 68.93; H, 7.04. Found: C, 68.98; H, 7.09.

5ba. Similarly, compound 4ba yielded 5ba (220 mg, 87%); mp 117–118 °C. EI-MS: m/z (%) = 340 [M⁺] (17), 323 (4), 205 (6), 178 (10), 149 (12), 134 (8), 121 (20), 49 (100). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C21H24O4: C, 74.07; H, 7.09. Found: C, 74.15; H, 7.17.

5bb. Compound 4bb gave 5bb (200 mg, 79%); mp 138–139 °C. EI-MS: m/z (%) 400 (34) [M⁺], 205 (24), 181 (100), 151 (12). For 1H and 13C NMR data see Tables 1 and 2. Anal. Calcd for C23H28O6: C, 68.93; H, 7.04. Found: C, 68.10; H, 7.06.

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References